$F_{g_1} = F_{g_2}$

$\frac{\cancel{G} M_1 \cancel{m}}{x^2} = \frac{\cancel{G} M_2 \cancel{m}}{y^2}$

$\frac{M_1}{x^2} = \frac{M_2}{y^2}$

$x + y = r$

M/m = $x^2/(r-x)^2$
Root(M/m)=k = x/(r-x)
k(r-x)=x
(1+k)x = kr
x = k/(1+k) x r
k = Sqrt(5.5E25/3.4E21)=127.1867547672921
x = 127.1867547672921/(1+ 127.1867547672921)=0.9921988819998
x = 0.9921988819998x(4.3E7+2.5E6)= 4.5145049130991E7 from planet centre

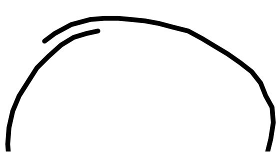
or 4.5 $\times 10^7$ from planet

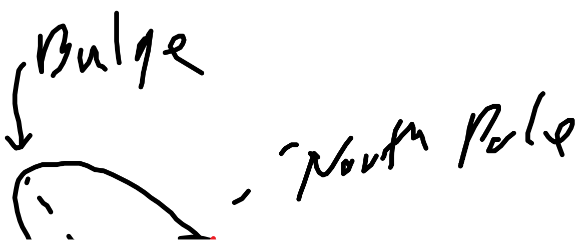
y = (4.3E7+2.5E6)-4.5145049130991E7= 354,950.8690090105 from moon centre

or 4400m from Moon

Gravitational Energy Handout
Hand back Quiz
Test next Wednesday

Q 1
North pole is closer to the centre (smaller r) because the Earth is not a perfect sphere (bulges in the centre)





$r_p < r_E$

$\therefore F_{gp} > F_{gE}$

but this only accounts for less than half
of the observed effect
9.78 to 9.82 N/kg
What accounts for the rest.

At the equator, all objects are partially in freefall due to the circular motion (spin).
What is the magnitude of this effect?

$a=4\pi^2 r/T^2 = 4\pi^2(6.38\text{x}10^6\text{m})/(24\text{h})^2$

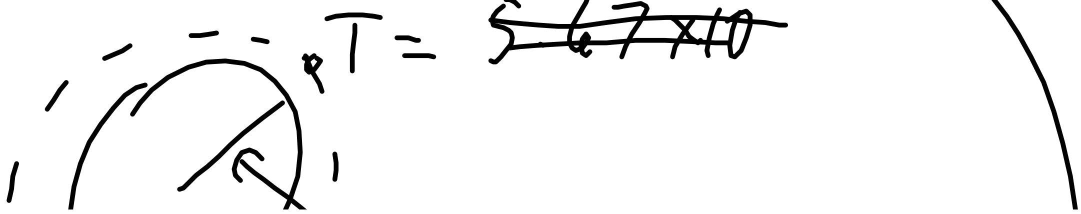
a = 4x3.14159^2x(6.38E6)/(24x3600)^2=

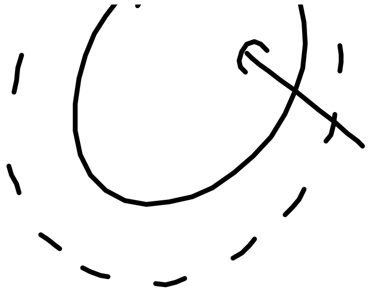
$0.03374\ \text{m/s}^2$ or N/kg

this is the difference btween 9.82-0.03=
9.79

Q2

T = ~~5.67x10~~ 102 minutes





3.43×10^{6} m

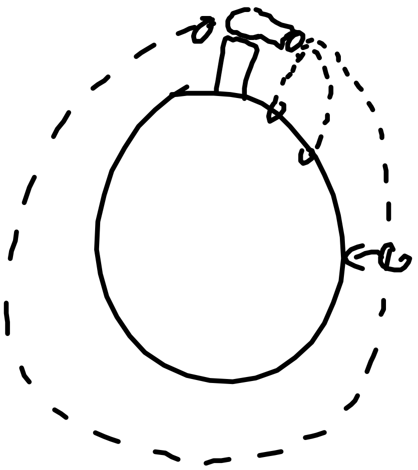
$$g=\frac{GM}{r^2}=\frac{4\pi^2 r}{T^2}$$

$4\pi^2r/T^2$
4x3.14159^2x(3.43E6)/(102x60)^2=
3.61535 = 3.62N/kg

g=a if no other forces

Q3
$a=4\pi^2r/T^2$
4x3.14159^2x(3.8E8)/(27.3x24x3600)^2=
0.0027 m/s^2

Q4



$$F_g=F_c$$

$$\cancel{m}g=\frac{\cancel{m}v^2}{r}$$

$$v=\sqrt{gr}$$

on orbit

$g \hat{=} 9.8$

v = Sqrt(9.81x6.38E6)=7,911.24516116142
7.9 x 10^3 m/s or 7.9 km/s

6.67E-11x5.98E24/(6.38E6)^2=9.7991

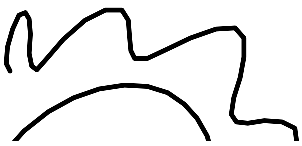
Q5 $4\pi^2 r/T^2$

4x3.14159^2x(1.5E11)/(365.25x24x3600)^2=
0.00595 m/s^2

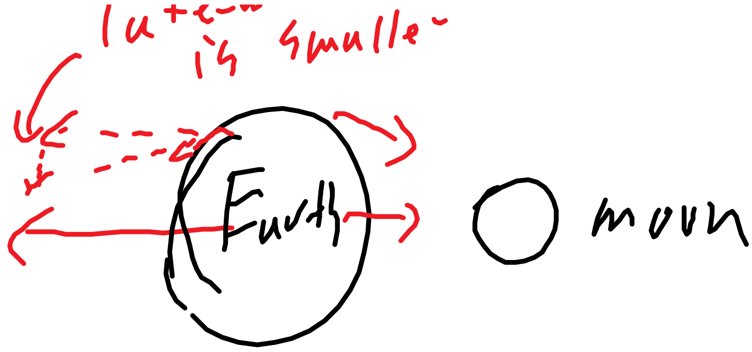
Q6 moon is accelerating at a smaller rate towards the Earth than the Earth is towards the Sun.
0.0027 m/s^2 vs 0.00595 m/s^2

Hey but the moon influences tides more than the sun, what's the deal?

The Sun is pulling more but the Earth is in freefall towards both Sun and moon, so the tides are caused by the difference in forces at different point. Think of it as the tangental components of the force.



lateral component is smaller



Eric - How do you find the mass of the Earth? (before Google?)
use G and r and Fg
How did they determine G?
Cavendish experiment of massive lead balls, some hanging on cables some close by and measure the attraction.

Q7 a, v and T are same
F_c is double F=ma

Q8 E_g = -GMm/r = -(6.67E-11x5.98E24x1)/(6.38E6)=-6.2518E7

-6.25×10^7 J

Q9 $\Delta E_g = -GMm\,(1/r_f - 1/r_i)$ not h!!!!!!!
-(6.67E-11x5.98E24x1)x((1/3.8E8)-(1/6.38E6))=6.1468E7
6.15×10^7J ignoring the pull of the moon

-(6.67E-11x7.35E22x1)x(-(1/3.8E8)+(1/6.38E6))=-755,507.9067
6.1468E7-755,507.9067=6.0712E7

6.07×10^7J including the pull of the moon

Q10 escape velocity
Et = Ek=-Eg
$1/2mv^2$ =GMm/r
v= Sqrt(2x6.67E-11x7.35E22/1.74E6)=
2,373.815494093844
2.4 km/s

Q11 E = GMm/r =
6.67E-11x(7.35E22)x(1000)/1.74E6=2.8175E9

2.8×10^9J required to remove 1000kg from moon

Earth
6.67E-11x(5.98E24)x(1000)/6.38E6=
6.2518E10
6.25×10^{10}J

6.2518E10/2.8175E9 = 22.1892 time the energy to release materials from Earth than moon.

$R = 2GM/c^2$ derive from vescape = c

v= root (2GM/r)
v^2 = 2GM/r
r = 2GM/v^2
set v=c definition of black hole - gravity is so strong light can't escape at event horizon

R = 2GM/c^2
r= 2x6.67E-11x1.99E30/(3.00E8)^2=
2,949.6222
about 3 km in radius

p147 Q58, 62, 63,64, 67, 68
p123 Q61,62 on the test